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Software Engineering Institute

Pittsburgh, PA 15213-3890

TRL Corollaries for Practice-Based Technologies (?)

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
MAY 2006		**00-00-2006 to 00-00-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
TRL Corollaries for Practice-Based Technologies (?)	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Carnegie Mellon University,Software Engineering Institute,Pittsburgh,PA,15213-3890**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002184. Presented at the Air Force Research Laboratory Seminar/Workshop on Multi-Dimensional Assessment of Technology Maturity in Fairborn, OH on 9-11 May 2006.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**20**	

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Purpose of this Presentation

To offer a potential set of TRL descriptions for use in assessing Practice-Based Technologies (PBTs)

To provide people who are thinking about using TRLs in different environments with ideas on how to go about analyzing your context to see if TRLs would be an applicable concept

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What are PBTs (Practice-Based Technologies)?

Practices
Processes
Methods
Approaches
Frameworks (for the above)

e.g.
- Product Line Practices
- CMMI (framework)
- Acquisition practices
- Transition processes

Versus non-PBTs:

Hardware
Software
Embedded systems
e.g. Biomedical devices

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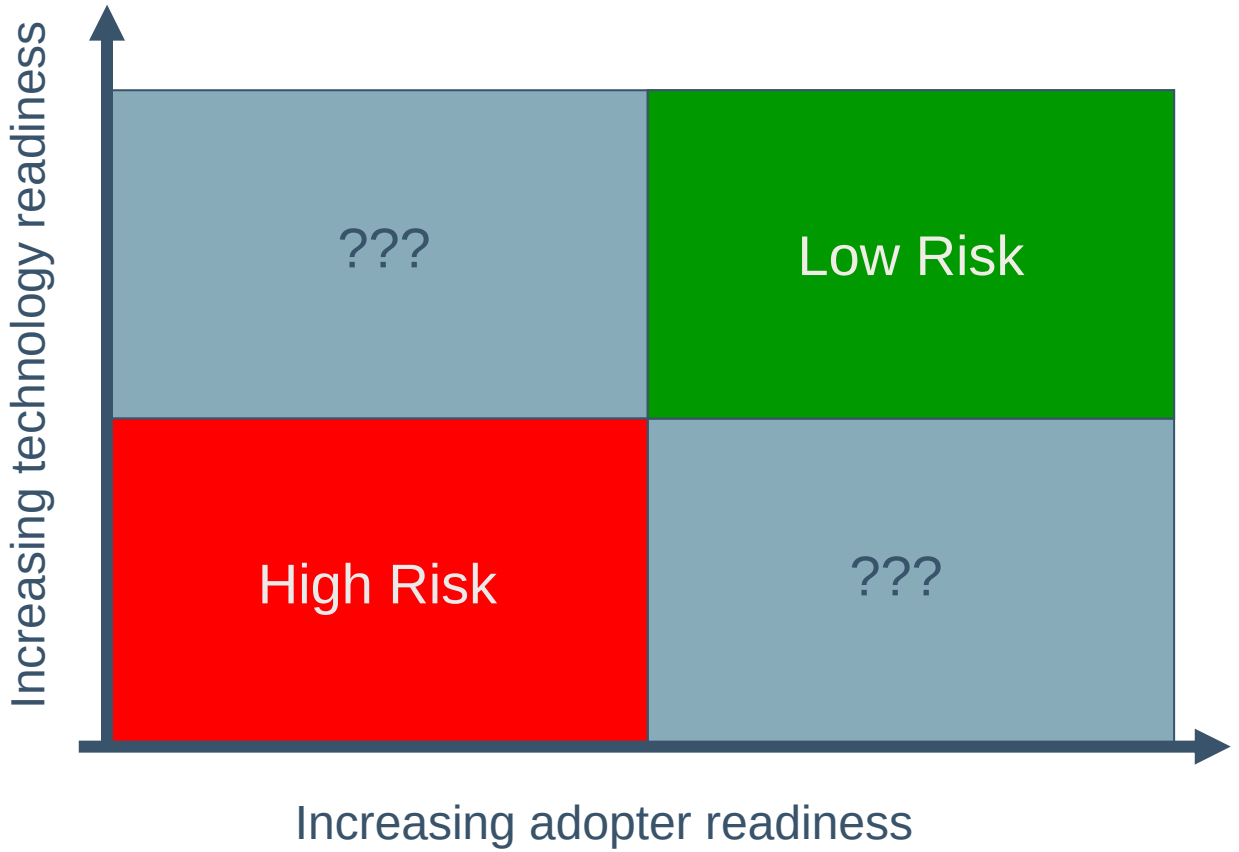
SEI View of (any) Technology Implementation Risk



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Why Should You Care about Applying TRLs to PBTs?

Improvement of acquisition, engineering, and management practices all require the implementation of PBTs

Knowing the “readiness” of a PBT could potentially be helpful (if we can come up with a valid characterization) in managing its implementation risks:

- “early” technologies may be suitable for some adopters, but require additional investment (to mature) for others
- “mature” technologies may be suitable for some, but offer no competitive advantage to others (because everyone has access to it)

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DoD Technology Readiness Levels Reminder

A scale from 1 to 9 used to assess technology maturity*

1. Basic principles observed and reported.
2. Technology concept and/or application formulated.
3. Analytical and experimental critical function and/or characteristic proof of concept.
4. Component and/or breadboard validation in laboratory environment.
5. Component and/or breadboard validation in relevant environment.
6. System/subsystem model or prototype demonstration in a relevant environment.
7. System prototype demonstration in an operational environment.
8. Actual system completed and qualified through test and demonstration.
9. Actual system proven through successful mission operations.

*DoD Interim Defense Acquisition Guidebook, October 30, 2002

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Why New TRL Descriptions Specifically for PBTs?

TRL users find current description difficult to interpret for non-hardware/system technologies

- e.g. software, medical, practices
- Study by SEI and Army CECOM in 2002 showed TRLs also not readily applied to information assurance PBTs

TRLs have gone a good ways beyond the “general” TRLs originally expressed:

- Army developed TRL descriptions for software
- Army Medical Research and Materiel Command developing TRL descriptions for biomedical technologies
- AFRL (Bill Nolte) is maturing a software tool for assessing TRLs along multiple dimensions

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TRLs Only Address One Side…

Especially with PBTs, TRLs are only one side of the equation:

- Technology maturity is worthless without adopter readiness
- The "fit" of the technology characteristics that affect adopter readiness is at least as important as any inherent maturity of the technology
  - SEI has developed a Readiness and Fit Analysis (RFA) technique for helping organizations understand adoption risks based on the fit of their organizational characteristics with the assumptions inherent in a particular technology
  - We see this is as a more productive direction for our research related to technology implementation than TRL assessment per se

Our Approach

Each TRL consists of

- a Definition, meant to be technology-independent
- a more detailed, technology-dependent Description

1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties

Our approach was to modify the *Description* for each level, leaving the Definition as is.

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Caveats

The Definitions are not really technology-independent (e.g., the term “breadboard”) but for those who want to use TRLs to assess non-hardware/system technologies, they’ll have to live with it if they want to be compliant with the TRL scale

TRLs are not the only criteria that support technology management, they are just one of numerous criteria

- *Users in the SEI/CECOM study estimated the TRL scale provides them, at most, 30% of their decision criteria*

This begs a question: should TRLs be expanded to appropriately become more of the decision criteria, or should TRL users be consistently explicit about the expectation of what other decision criteria should be involved in different decision contexts?

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The 2 Dimensions Addressed by DoD TRLs

For hardware/systems, TRLs 1-9 depict the following general progression in readiness:

- The environment in which the technology can function becomes more representative of the final operational environment
  - from paper studies through laboratory setup, simulated environments, to mission operations
- The completeness of the technology increases
  - from basic properties through breadboard components, integrated components, prototype, to final form

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What Does this Mean for PBTs?

The environment in which the technology can function becomes more representative of the final operational environment *(a community of users)*

- *for PBTs this means the community of users expands from initial risk takers to more mainstream members of the community*

The completeness of the technology increases

- *For PBTs this means the technology progresses from defined basic properties through defined core practices, implementation mechanisms, best practices, to a body of knowledge*

Key Differences

The operating environment for PBTs is people/organizations/community, not hardware/systems

PBT environment is more mutable, malleable, in flux

These differences, and our experience of the innate 2 dimensional nature of technology adoption, makes us somewhat nervous about the long term utility of TRLs for PBTs

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PBT Corollaries – SEI draft

TRL	HW/System	Practice-Based Technologies
1	Scientific research, paper studies	Scientific, behavioral, and market research, paper studies
2	Practical, speculative applications invented	Practical, speculative applications invented, potential user communities identified
3	Active R&D initiated, analytical and lab studies of components	Active R&D initiated, critical elements identified and demonstrated with innovative users
4	Basic components integrated, lab environment	Basic elements integrated to form core PBT, visionary leaders used to demonstrate value and transitionability
5	Integrated components demonstrated in simulated environment	Prototypes of implementation mechanisms established, demonstrated with core PBT for pragmatic users in simulated environments, such as role-based workshops
6	Prototype tested in relevant environment	Implementation mechanisms refined and integrated with core PBT, demonstrated in relevant environments, e.g., pilot settings
7	Actual system prototype in operational environment	Implementation needs of mainstream users identified and integrated into the prototype, operational use by relevant users demonstrated across the community
8	Final form proven to work in operational environment	Technology picked-up for wide-spread rollout across the community
9	Actual application running under mission conditions	PBT use is considered routine within community; best practices and body of knowledge are in place

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Testing Our PBT Corollaries Using a Retrospective Approach

Before using TRLs for PBTs in a *predictive* manner, we believe it prudent to apply them retrospectively to see if the PBT TRLs provide insights into the evolution of a technology that we have a long history with

- SW-CMM was selected as a PBT that has sufficient history to investigate the insights that could be gained with this approach

Notable results of analysis:

- Use of the retrospective process helped us to refine some of the boundaries among the draft TRLs
- Generally belief is that we were able to characterize relevant aspects of SW-CMM evolution
- Still struggling somewhat with how to deal with technology "upgrades" (ie SW-CMM → CMMI) in PBT context

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Example: SW-CMM -1

TRL #	Key Characteristics	SW-CMM based Improvement Example	Nominal Timeframe
1	Scientific, behavioral, and market research, paper studies	IBM software framework research, Crosby research, Humphrey proposal of 5-level maturity framework	1985-1987
2	Practical, speculative applications invented, potential user communities identified	Initial questionnaire developed/published (87-TR-13), DoD and its sw-intensive system suppliers identified	1986-1987
3	Active R&D initiated, critical elements identified and demonstrated with innovative users	SPA, 87-TR-13 used with large DoD organizations and contractors; *Managing the SW Process* book published	1987-1989

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Example: SW-CMM -2

4	Basic elements integrated to form core PBT, visionary leaders used to demonstrate value and transitionability	SW-CMM initial design prototyped/tested	1989-1991
5	Prototypes of implementation mechanisms established, demonstrated with core PBT for pragmatic users in simulated environments, such as role-based workshops	SW-CMM v1.0 published; piloted with wider user base; SPA and SCE used to feed back info to CMM dev team; SEPG workshop becomes SEPG conference	1991-1993
6	Implementation mechanisms refined and integrated with core PBT, demonstrated in relevant environments, e.g., pilot settings	SW-CMM v1.1 published; Intro training, CBA-IPI and lead appraiser program developed; ROI case studies published	1993-1995

Example: SW-CMM -3

7	Implementation needs of mainstream users identified and integrated into the prototype, operational use by relevant users demonstrated across the community	Transition Partner, CBA-IPI, SCE 3.0, Intro TTT established; SW measurement books published; process support (proc defn, MPI) courses developed; SW-CMM v2.0 drafted	1993-1997
8	Technology picked-up for wide-spread rollout across the community	"YAMMs" phenomenon; high maturity workshops established; principles for CMM established; SW-CMM v2.0 chosen as basis for CMMI framework	1995-1997
9	PBT use is considered routine within community, best practices and body of knowledge are in place, may involve incorporation of the technology into community guidance and policy	Incorporation of CMM concepts into ISO 15504; over 60 orgns invited to 2001 high maturity workshop; noticeable improvement in maturity profile for intended community; SW-CMM subsumed into CMMI (broadening overall community)	1997-2001

Summary and Next Steps

Potential draft of TRL Descriptions for PBTs has been defined here

- No funding is allocated for going beyond this stage

Community feedback and participation welcome (send email to cpg@sei.cmu.edu or smg@sei.cmu.edu)

Next steps possibilities:

- Incorporate a PBT TRL assessment as part of Readiness & Fit Adoption Risk Analysis
- Further explore the effects of using a single scale to represent a (at least!) two dimensional situation

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For more information…

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